STEP-WISE PROCEDURE FOR CALIBRATING BANKFULL DISCHARGE AT USGS STREAMGAGING STATIONS

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STEP 10 - Calculate manning's "n" or other resistance equations from actual velocity for bankfull and/or other flows.

STEP 11 - Use special forms for use at streamgage sites as shown in exhibit 8.

STEP 12 - Use checklist for complete morphological description (dimension, profile, and pattern) (exhibit 9). This information will be used to establish a data base for use in river assessment and restoration.

STEP 1 - Obtain the following information for the streamgage

1. Location (including location of current meter measurement sites).
2. Drainage area (square miles).
3. Stage/discharge curve (gage height/discharge rating table) (exhibit 1).
4. Stream discharge notes (9-207) for last 10 years or widest range of measured discharge (data for depth, width, velocity, and cross-sectional area/discharge) (exhibit 2).
5. Flood frequency data (Log -Pearson) if previously published, if not obtain:
    a. Listing of highest momentary maximum flows for period of record.
    b. Ranking of flood peaks (highest to lowest).
    c. Calculate (m/N+1)x100, where m = rank, N = number of years of record. This calculation gives exceedance probability for a respective flood peak which allows a determination of return period of the various peak flows. The data and respective plotting positions are plotted on probability paper and a line is drawn to connect the points (exhibit 3).

STEP 2 - Travel to gage site and observe bankfull "indicators" along river reach. Measure a longitudinal profile upstream of gage, locating elevations of bed, water surface and bankfull stage elevations. Mark bankfull stage along profile with temporary flags, then measure this stage at the gage height staff reference at the streamgage cross-section. Record the gage height (staff plate) reading.

STEP 3 - Read discharge from rating table of streamgage corresponding to gage height of the "field estimated" bankfull stage.

STEP 4 - Read exceedance probability associated with field determined bankfull discharge (from step 3). To convert exceedance probability (P) to return period in years: (1/Px100).

STEP 5 - If the return period of the field determined bankfull discharge is within 1-2 years, the bankfull indicators are within the range of acceptability for use.

STEP 6- Plot bankfull discharge vs drainage area for the appropriate hydro-physiographic province associated with the streamgage (exhibit 4).

STEP 7 - Plot hydraulic geometry relations from the stream discharge notes, including : depth, width, cross-sectional area and velocity (exhibit 5).

STEP 8 - Plot *bankfull* values of depth, width, and cross-sectional area onto regional curves by drainage area (exhibit 6).

STEP 9 - Complete reference reach form for stream classification (level II), classify stream type. In plotting data (steps 7 and 8) stratify or note data by stream type with a unique symbol (exhibit 7).

EXHIBIT 4

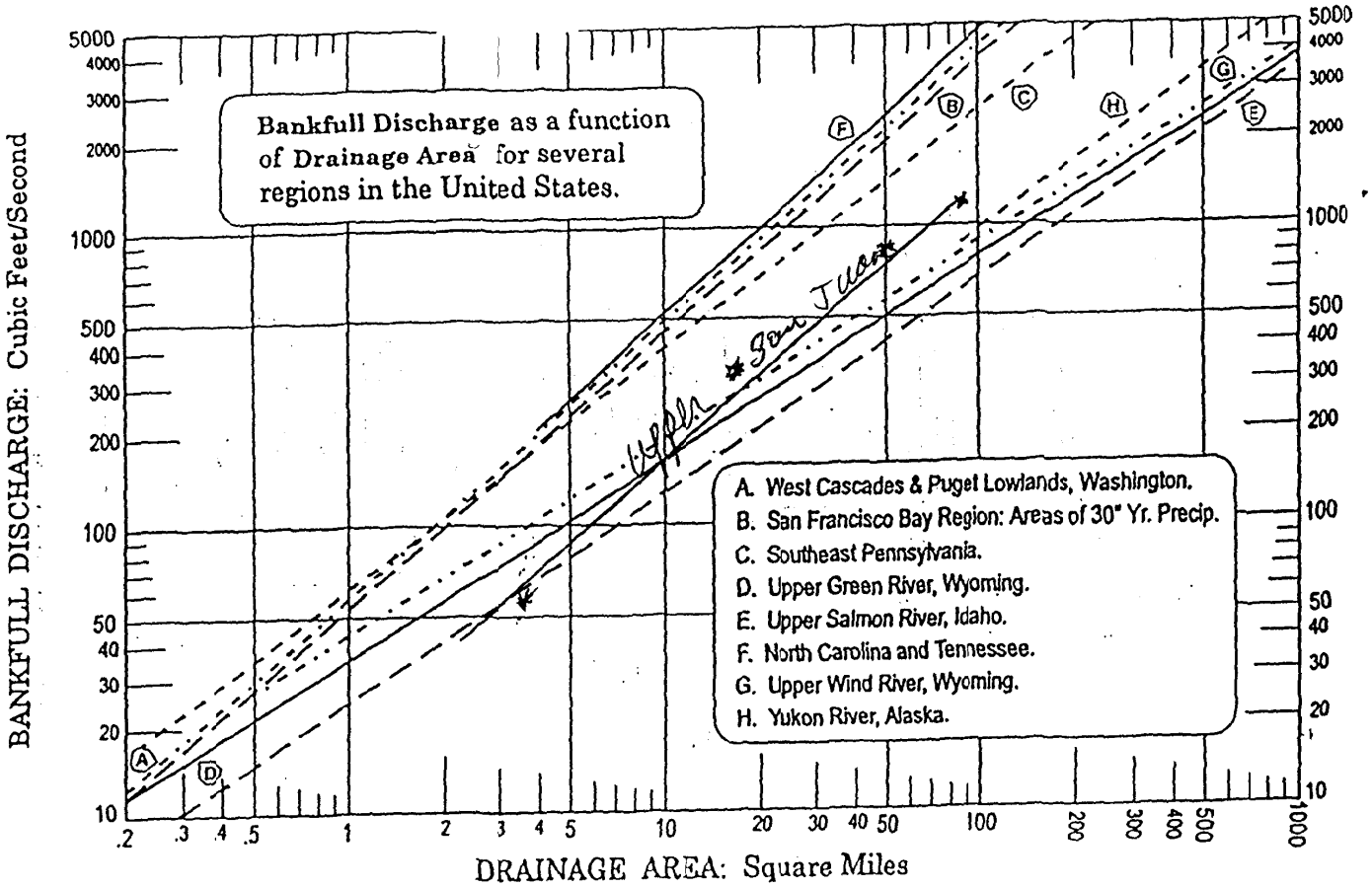

Bankfull Discharge as a function of Drainage Area for several regions in the United States.
A. West Cascades & Puget Lowlands, Washington.
B. San Francisco Bay Region: Areas of 30" Yr. Precip.
C. Southeast Pennsylvania.
D. Upper Green River, Wyoming.
E. Upper Salmon River, Idaho.
F. North Carolina and Tennessee.
G. Upper Wind River, Wyoming.
H. Yukon River, Alaska.
BANKFULL DISCHARGE: Cubic Feet/Second
DRAINAGE AREA: Square Miles
5000
4000
3000
2000
1000
500
400
300
200
100
50
40
30
20
10
.2
.3
.4
.5
1
2
3
4
5
10
20
30
40
50
100
200
300
400
500
1000

EXHIBIT 5

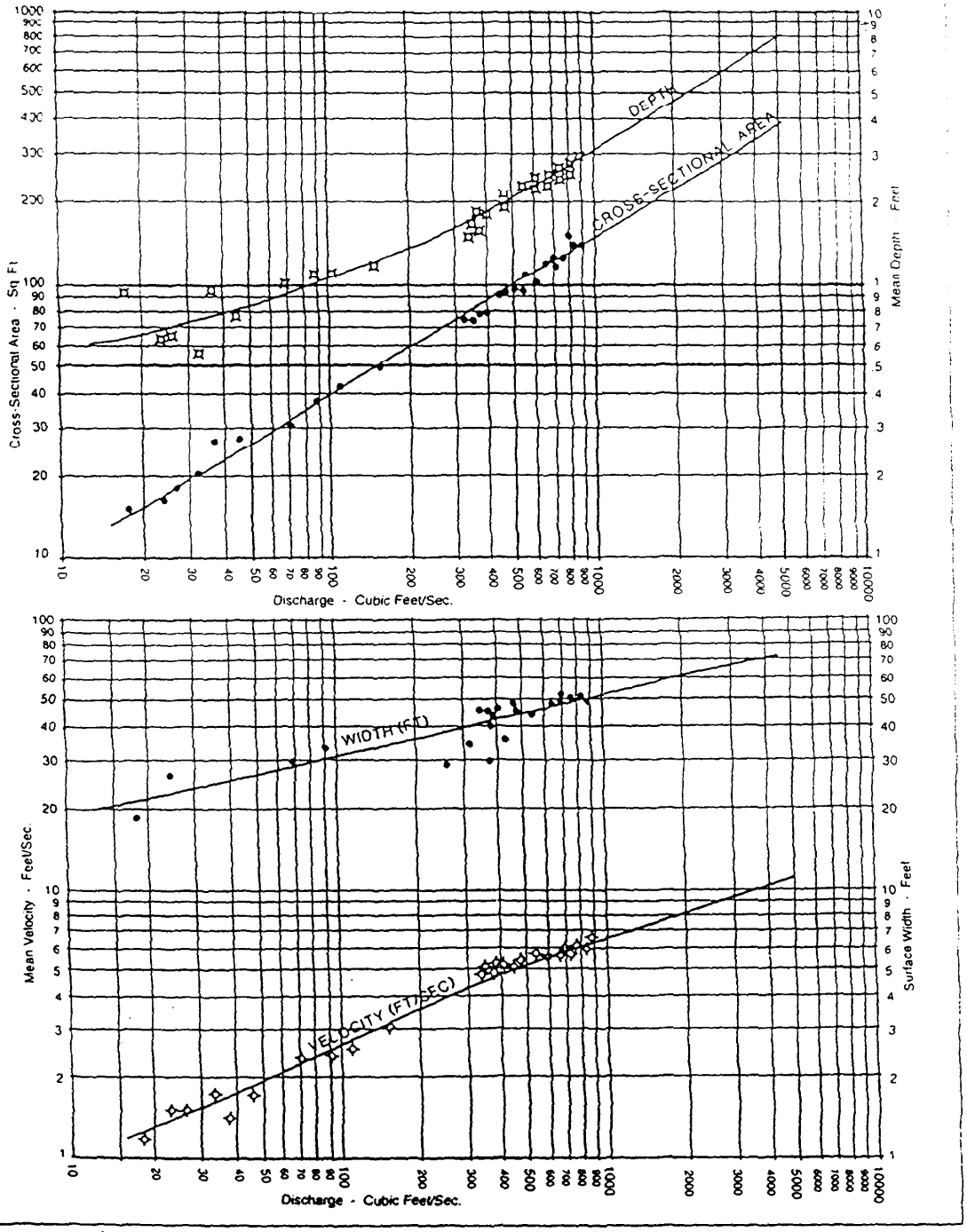
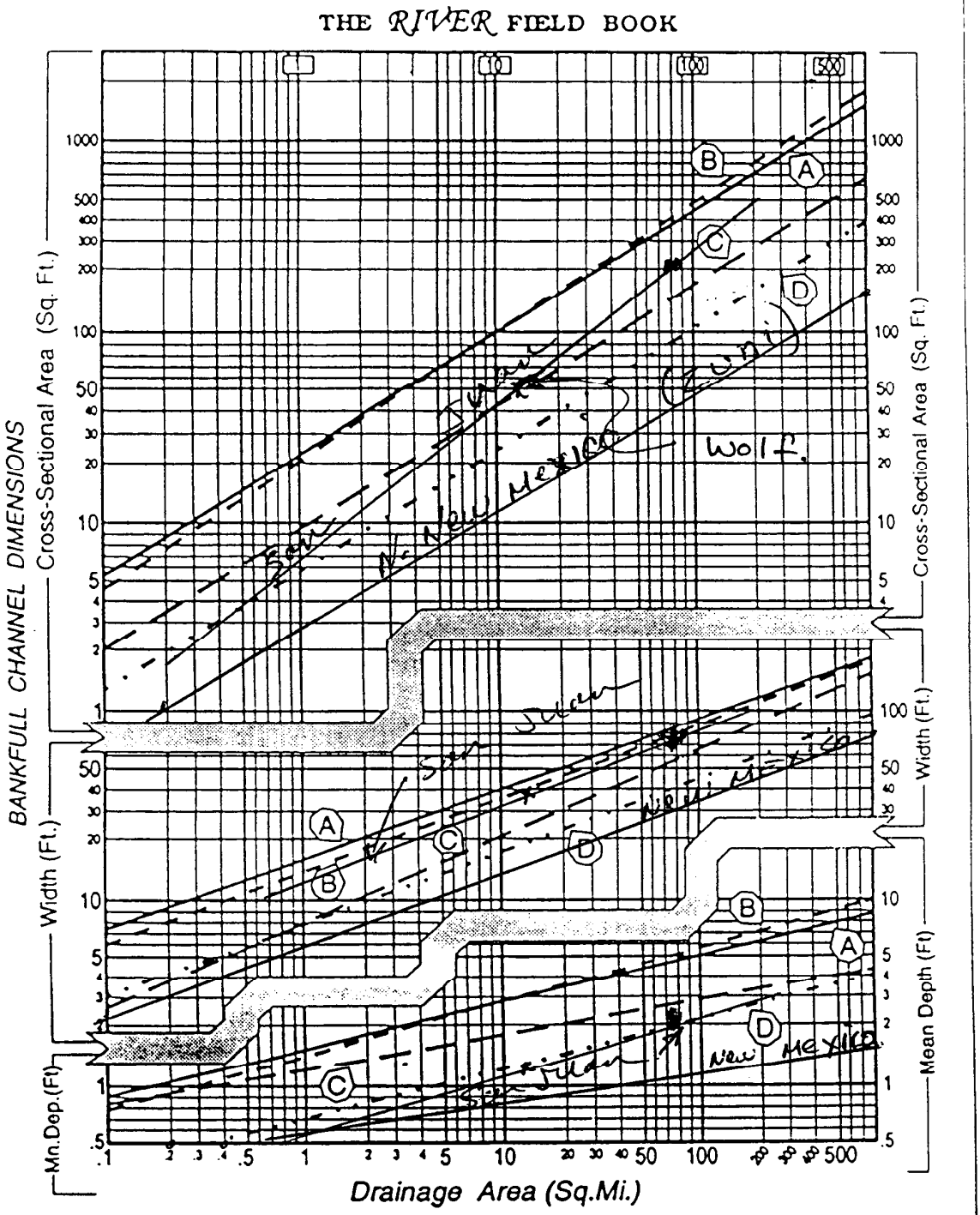


FIGURE 7-3. An example of hydraulic geometry data analyses as developed from U.S. Geological Survey data for the East Fork of the San Juan River, Colorado.

EXHIBIT 6



Average Values of Bankfull Channel Dimensions as Functions of Drainage Area, for Four Regions

A: San Francisco Bay region at 30" annual precipitation.

B: Eastern United States

C: Upper Green River, Wyoming.

D: Upper Salmon River, Idaho. (Emmett 1975)

EXHIBIT 7

TABLE 5-3. Reference reach field data form for stream classification.

REFERENCE REACH FIELD FORM
STREAM CHANNEL CLASSIFICATION **LEVEL II**

STREAM TYPE:_____

STREAM NAME: _____ DRAINAGE AREA: _____ BASIN NAME: _____

OBSERVERS: _____ DATE: _____

LOCATION: _____ Twp._____ Rge._____ Sec. _____ Qtr. _____

Bankfull WIDTH _____Ft. (W_{bkf})
Bankfull Mean DEPTH _____Ft. (d_{bkf})
WIDTH/DEPTH Ratio _____

Bankfull MAX> DEPTH _____Ft. (d_{max})
Flood Prone Area WIDTH _____Ft. (W_{FP})
ENTRENCHMENT Ratio _____

Channel SLOPE_____Ft/Ft _____%
Valley SLOPE_____Ft/Ft _____%
SINUOSITY (Stream Dist/Valley Dist.) _____

Channel MATERIALS: (Pebble Count) D15_____mm D34_____mm D50_____mm D84_____mm D95_____mm

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EXHIBIT 8

TABLE 5-2. Sample form for recording gage station and field data

SUMMARY of USGS GAGE DATA/RECORDS for STREAM CHANNEL CLASSIFICATION

Station NAME: _____ Station NUMBER: _____

LOCATION: _____

Period of RECORD: _____Yrs. Percentage of Watershed Hydraulically Impacted _____%

Drainage AREA: _____Ac. _____Sq.Mi. Drainage MEAN ELEVATION: _____Ft.

Reference REACH SLOPE: _____ STREAM TYPE: _____

BANKFULL CHARACTERISTICS

Determined by FIELD MEASUREMENT		Determined by GAGE DATA Analyses	
Bankfull WIDTH	Ft. (W_{bkf})	Bankfull WIDTH	Ft. (W_{bkf})
Bankfull MEAN DEPTH	Ft. (d_{bkf})	Bankfull MEAN DEPTH	Sq. Ft. (d_{bkf})
Bankfull STAGE	Ft.	Bankfull STAGE	Ft.
Bankfull Xsec. AREA	Sq. Ft. (A_{bkf})	Bankfull Xsec. AREA	Sq.Ft. (A_{bkf})
Wetted PERIMETER	Ft. (WP)	Wetted PERIMETER	Ft. (WP)
Est. Mean VELOCITY	Ft./Sec. (V_{bkf})	Bankfull Mean VELOCITY	Ft./Sec. (V_{bkf})
Est. Bankfull DISCHARGE	Cfs (Q_{bkf})	Bankfull DISCHARGE	Cfs (Q_{bkf})

Bankfull DISCHARGE associated with *"field determined"* Bankfull STAGE: _____Cfs. (Q_{bkf})
(From Gage Height reading at Staff Plate and tabular Stage-Discharge Curve Data)

Recurrence Interval (Log-Pearson) associated with *"field determined"* Bankfull Discharge
R.I.=_____Years

From the *Annual Peak Flow Frequency Analysis* data for the Gage Station, determine:
1.0 Year R.I. Discharge=_____CFS
1.5 Year R.I. Discharge= _____CFS
2.0 Year R.I. Discharge= _____CFS

MEANDER GEOMETRY

Determined by FIELD MEASUREMENT

Meander Length (L_m)_____Ft. Radius of Curvature (R_c) _____Ft.

Belt Width (W_{blt}) _____Ft. Meander Width Ratio (W_{blt}/W_{bkf}) _____

HYDRAULIC GEOMETRY

Based on *USGS Discharge Summary Notes* data (Form 9-207) and regression analyses of measured discharge (Q) with the hydraulic parameters of Width (W), Area (A), Mean Depth (d), Mean Velocity (V); determine the *intercept coefficient* (a) and the *slope exponent* (b) values for a power function of the form $Y=aX^b$; when Y is one of the selected hydraulic parameters, and X is a given discharge value (Q).

	Width (W)	Depth (d)	Area (A)	Velocity (V)
Coefficient (a)				
Slope Expn. (b)				

Hydraulic Radius (R=A/WP) _____Ft. Manning's "N" (Rough. Coeff.) at Bankfull Stage _____

"N"=1.486 / Q_{bkf} [(Area) (Hydraulic Radius ^2/3) (Slope ^1/2)]

EXHIBIT 9

TABLE 5-1.Checklist of recommended Procedure @ USGS Gage or other streamflow measurement locations

A. Describe Site
   1. Geomorphic Setting - Valley Types I through XI. See chapter 4 for descriptions.
   2. Channel Materials (Pebble Count) (D16, 35, 50, 84, 95)
      a. Bed Material - Pebble Count
      b. Bank Material - Pebble Count and core sample
      c. Bar Material - core sample
   3. Locate on Topographic Map
   4. Photo Document - Up/Downstream
   5. Compute percentage of Watershed Hydraulically Impacted

B. Longitudinal Profile
   1. Measure Average Water Surface Slope
      a. Riffle Slope
      b. Pool Slope
   2. Measure Valley Slope
   3. Sequence of Riffle/Pool or Step/Pool as a function of Bankfull Width
   4. Locate Bankfull Stage along Longitudinal Profile

C. Plan View
   1. Measure Sinuosity (SL/VL) (VS/CS), where: SL=stream length; VL=valley length; VS=valley slope; and CS=channel slope
   2. Meander Geometry
      a. Meander Length (LM)
      b. Belt Width (BW)
      c. Radius of Curve (RC)
      d. Meander Arc Length (ML)
      e. Meander Width Ratio

D. Cross-Section (Dimension)
   1. Cross-section of Channel + Valley Features - Terrace/Floodplain (to be identified on cross-section plot).
      a. Bankfull Width (W_{bkf})
      b. Bankfull Mean Depth (d_{bkf})
      c. Bankfull Maximum Depth (d_{mbkf})
      d. Flood Prone Area Width (W_{fpa})
      e. Entrenchment Ratio (W_{fpa}/W_{bkf})
      f. Bankfull Cross-sectional Area (A_{bkf})
      *g. Bankfull Velocity (U_{bkf})
      h. Estimated Bankfull Discharge (Q_{bkf})

**Estimate from various sources.*

   2. Calibrate Bankfull Estimates
      a. Survey Estimated Bankfull Stage
      b. From gage plate, extrapolate stage reading associated with estimated "Bankfull"
      c. Read Discharge from Rating Curve @ Gage (Stage/Discharge Relation)
      d. Determine recurrence interval in years from flood frequency curves at station. (Should be 1-2 years or average of 1.5 year Q).
      e. Analyze hydraulic geometry data from 9-207 forms (discharge notes) for width, depth, velocity and cross-sectional area vs. stream discharge. Plot data on logalog paper and run a regression to obtain slope and intercept values for each variable.
      f. Develop dimensionless hydraulic geometry relations. This is to be applied for extrapolation purposes to rivers of the same stream type, but for various sizes. W/W_{bkf} vs Q/Q_{bkf} (Complete for depth, velocity and cross-sectional area).